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METHOD FOR DETERMINING PULSE WAVE VELOCITY

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ABSTRACT

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Determination of pulse wave velocity is regarded as a very promising method for diagnosing arteriosclerosis. The author describes a new method for calculating pulse wave velocity by means of a cardiograph. Results obtained by this method coincide with data given in the literature.

The determination of the pulse wave velocity is a valuable diagnostic /142* method in an internal disease clinic. In a scheduled report given at the 14th All-Union Congress of Internists, A. L. Myasnikov felt that this method is very promising for diagnosing arteriosclerosis, and distinguished it from several other instrument research methods. According to the observations of L. K. Lakshina and Yu. T. Pushkar', when arteriosclerosis is present the pulse wave rate sharply increases up to 15-25 m/sec, as opposed to 5.5-8 m/sec.

N. N. Savitskiy has given considerable attention to the pulse wave velocity, assuming that "the change in the pulse wave propagation velocity is one of the most reliable indices of the viscoelastic condition of the vascular walls and makes it possible to characterize in quantitative terms the elastic

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* Note: Numbers in the margin indicate pagination in the original foreign text.

stress of a vessel, and of the vascular walls with sufficient accuracy". [1] A knowledge of the pulse wave velocity is necessary for determining the cardiac output in physical methods, and for clarifying several other important indices regarding the functional state of the circulatory system. These have been discussed in detail in the recently published monograph by N. N. Savitskiy.

T. Brungsch believes that a determination of the pulse wave velocity can facilitate a study of several cardiology problems, particularly the problems of collapse and arteriosclerosis; he refers to the data of Duesberg, and Shreder contained in the study by O. Frank, Wezler, and Boger. However, for technical reasons this research method has not yet found proper application in clinical practice, and has not left the confines of scientific research laboratories, both in the Soviet Union and abroad. In particular, Brungsch - while assuming that a determination of the pulse wave velocity is very valuable - notes with regret that this method cannot be applied extensively in clinical practice, because it requires a very careful technique which can be achieved only in a well-equipped scientific research laboratory.

The principles underlying the determination of the pulse wave velocity are very well known. They are based on utilization of two sensitive /143 sphygmographs which record a sphygmogram simultaneously from two arteries located at different distances from the heart. By determining the delay time of a pulse wave at a section of the artery which is farther from the heart (Δt), and the difference in the length of the artery (1), one can find the pulse wave velocity in meters per second according to the formula: C (pulse wave velocity)

[1] N. N. Savitskiy. Some Methods of Studying and Functionally Evaluating the Circulatory System (Nekotoryye metody issledovaniya i funktsional'noy otsenki sistemy krovoobrashcheniya). Medgiz, p. 80, 1956.

$= \frac{1}{\Delta t}$. Thus, the determination of the magnitude (time) of a peripheral pulse delay is a basic factor in calculating the pulse wave velocity.

Several factors are involved in an applicable method.

1. A special, very sensitive apparatus is requisite; this apparatus must simultaneously record two sphygmograms on one tape.

2. In order to determine the pulse delay, it is necessary to know the "concurrent points" of the sphygmograms. This is difficult, because the sphygmograms which record from different arteries differ in form. Meiners, who made a special study of this problem, believes that the determination of the truly "concurrent points" represents the main difficulty of this method.

3. The recording method of the sphygmograms, and the technical construction itself of the sphygmograph employed - which, in the opinion of Meiners, contributes to different authors obtaining comparable results - influence the method to a significant extent.

For practical purposes, we employed another method for determining the magnitude (time) of the pulse wave delay. The electrocardiogram and the mechanical oscillation - sphygmogram (by means of a piezoprobe) - are simultaneously recorded on a single channel EKP-4 electrocardiograph. For this purpose, the piezoprobe, which was constructed at our institution by engineer N. G. Yakovlev, is placed on the artery to be studied, and is connected to the electrocardiograph circuit in series with electrodes which are fastened to the extremeties, since this is done during electrocardiogram recordings with standard leads.

During the "superposition" of the sphygmogram on the electrocardiogram, there is always a clearly-expressed peak R of the electrocardiogram and a peak of the piezograph recording of the pulse oscillation (we have used the letter A to conditionally designate that of the anacrote). The distance between these peaks (the interval RA) is determined according to the time marking (one division equals 0.05 seconds in the EKP-4).

By thus recording the combined electrocardio-sphygmograms from arteries located at different distances from the heart (the carotid, the femoral, the radial, etc.), we can obtain a recording with a different duration of the RA interval: The farther the artery is from the heart on which the piezoprobe is placed, the longer the RA interval. The peak R, from which the measurement begins, is a constant starting point, which provides a redundent simultaneous recording of the two sphygmograms. A sharp rise in the R and A peaks facilitates the determination of the "concurrent points" (the apexes of the peaks or the point at which the curves begin to rise) on the recordings to be compared. The delay time of the pulse rate Δt is determined by subtracting the RA intervals on the recordings from different arteries.

Example

RA on the dorsal artery of the foot equals 0.37 seconds.

RA on the radial artery equals 0.23 seconds.

$\Delta t = 0.37 - 0.23 = 0.14$ seconds.

The pulse wave velocity can be further calculated by the normal method: The distance from the cavity of the breastbone up to the dorsal artery of the foot (in the example given by us) is 159 cm; the distance to the radial artery at the place where the recorder is located is 71 cm.

$1 = 159 - 71 = 88$ cm.

The pulse wave velocity = 88 cm: 0.14 sec = 6.3 m/sec.

The results obtained by the method we have described coincide with the /144 average data given in the literature.

For purely practical purposes, it would be advantageous to employ the index RA, obtained by dividing the artery length by the interval RA, instead of the pulse wave velocity. This considerably simplifies the method (the recording is made from only one artery when the sphygmogram peak is superposed on the electrocardiogram), and provides an idea of the elastic properties of the vascular wall. A calculation of the RA index would be useful for making comparisons on symmetrical arteries (for example, at the lower extremities when they are selectively injured, and in several other cases).

The method we have proposed for calculating the pulse wave velocity is simple for practical purposes, and can be performed in any clinic which has an electrocardiograph available. This makes it possible to employ it in daily clinical practice, thus expanding the diagnostic possibilities in several diseases of the cardiovascular system.

REFERENCES

1. Myasnikov, A. L. Abstract of Report to XIV All-Union Congress of Internists (Tez. dokl. na XIV Vses. s'yezde terap.), Moscow, pp. 7-11, 1956.

2. Savitskiy, N. N. Certain Methods of Studying and Functionally Evaluating the Circulatory System (Nekotoryye metody issledovaniya i funktsional'noy otsenki sistemy krovoobrashcheniya), 1956.

3. Brungsch, T. Cardiology (Kardiologie), 4th Edition, S. Hirzel Verlag. Leipzig, p. 71, 93, 512, 1955.

4. Meiners, S. Krieslaufforsch, Vol. 43, No. 9/10, pp. 297-307, 1954.

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